SCIENCE

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A Nuclear Research Institute at Oak Ridge

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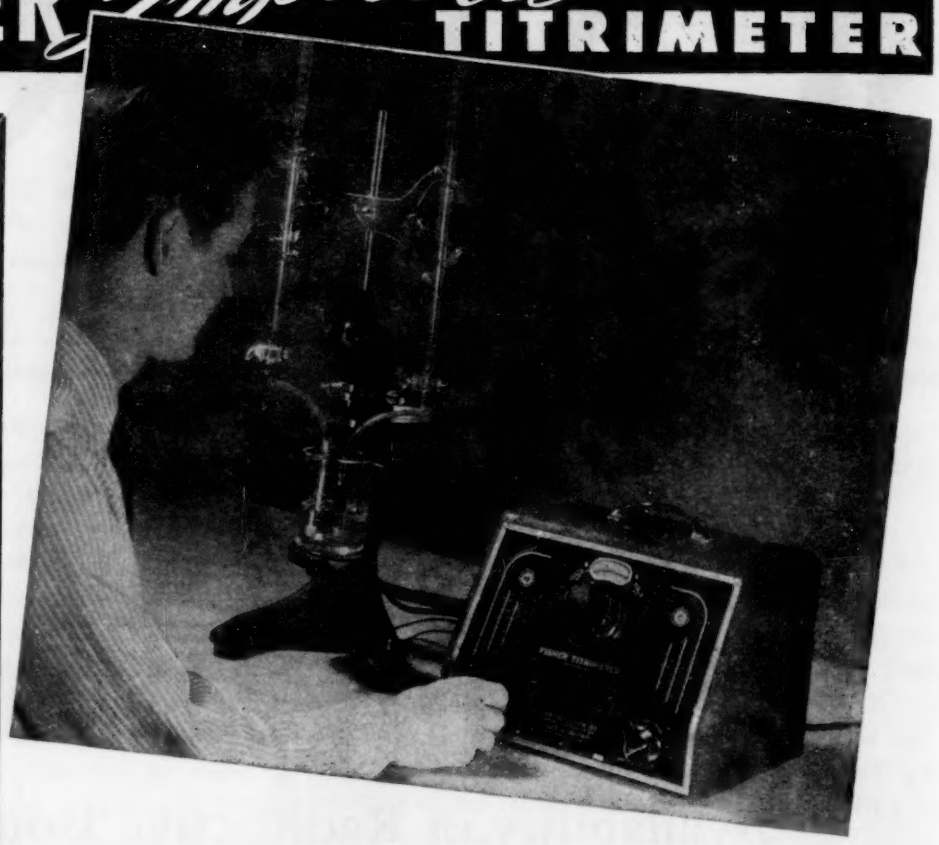

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SCIENCE

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Availability of Radioactive Isotopes

Announcement From Headquarters, Manhattan Project, Washington, D.C.

PRODUCTION OF TRACER AND THERAPEUTIC RADIOISOTOPES has been heralded as one of the great peacetime contributions of the uranium chain-reacting pile. This use of the pile will unquestionably be rich in scientific, medical, and technological applications.

Manhattan Project scientific, technical, and administrative personnel have, since the inception of the pile, been cognizant of its peacetime potentialities and have, since the end of the war, been active in attempting to realize these opportunities. Since, however, war-built piles and wartime researches had other objectives, a considerable transition in researches, developments, and operations connected with piles must be effected before the supply of radioisotopes can begin to meet the demand.

Comments on Availability of Radioisotopes

(1) A pile cannot make the extensive variety of radioisotopes producible with the cyclotron because the cyclotron makes use of a much greater diversity in energy and type of nuclear bombarding projectiles. Present piles are copious sources of low-energy neutrons, which can give rise to large yields only of isotopes produced by (n,f) and (n,γ) processes.

(2) Although large numbers of radioisotopes are produced in abundance by the fission of uranium in the piles, their availability is limited by the difficulties encountered in isolating them. It has not yet been found feasible to remove individual fission products from waste solutions of the plutonium extraction process. Most of the fission products being made available are not salvaged by-products of the plutonium process but are in each case items requiring special production from unprocessed irradiated uranium.

(3) Most of the radioisotopes in greatest demand, such as C 14, S 35, and P 32, must be produced by the irradiation of materials foreign to the pile. Existing piles were not designed for this purpose.

(4) Although a pile is a copious source of neutrons, it is not a limitless source. It is possible to load a pile for nonfission product radioisotope production only up to the limit at which so many neutrons are absorbed in the introduced material that the chain reaction ceases even though the control rods are withdrawn as far as feasible. With available pile facilities, this limit does not permit the production of a sufficient quantity and quality of many radioisotopes to meet anticipated national demands. To accomplish this it would very likely be necessary to build piles especially designed for the purpose.

(5) Technical problems involved in the irradiation of some materials have been, and will continue to be, responsible for delays in making certain isotopes available by routine irradiation. Examples of such problems are: (a) proper canning of the material to prevent rupture of the container by its internal action or by the external action of the coolant, with consequent loss of the material and damage to the pile; (b) careful purification to prevent loss of neutrons by absorption in impurities as well as undesirable radioactivity in the irradiated material; and (c) proper distribution of the material throughout the pile to prevent local overheating or undesirable regulation characteristics of the pile.

Organization for Allocation and Distribution

In accordance with the established custom of the Manhattan Project of seeking competent outside advice and aid on vital scientific matters, such as nonproject distribution of isotopes, Maj. Gen. L. R. Groves asked the president of the National Academy of Sciences to nominate a representative committee of outstanding scientists to recommend policies and aid in establishing arrangements for a desirable distribution of those tracer and therapeutic isotopes available from Manhattan Project facilities. An interim Advisory Committee on Isotope Distribution Policy was formed, two representatives being chosen from each of the major fields of isotope application: Physics—Lee A. DuBridge (chairman), head, Physics Department, University of Rochester, and president-elect of California Institute of Technology, Pasadena; and Merle A. Tuve, head, Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, D. C.; Chemistry—Linus Pauling, director, Gates and Crellin Chemistry Laboratories, California Institute

of Technology; and Vincent du Vigneaud, head of the Department of Biochemistry, Cornell University Medical College, New York City; Medicine—Cornelius P. Rhoads, director of Memorial Hospital, New York City, and chairman of the Committee on Growth of the National Research Council; and Cecil J. Watson, head of the Department of Medicine, University of Minnesota Medical School, Minneapolis; Biology—Raymond E. Zirkle, professor of botany and director of the Institute for Biophysics and Radiobiology, University of Chicago, Chicago, Illinois; and A. Baird Hastings, head of the Department of Biological Chemistry, Harvard University Medical School, Cambridge; Applied Science—Zay Jeffries, vice-president and manager of Chemicals Department, General Electric Company, Pittsfield, Massachusetts; and L. F. Curtiss, chief of the Radioactivity Section, National Bureau of Standards, Washington, D. C. Paul C. Aebersold, chief of the Isotopes Branch, Research Division, Manhattan District, was chosen acting secretary to coordinate the efforts of the Committee and to effect liaison with the Project.

The recommendations of this Committee on a suitable interim mechanism for allocation and distribution have been adopted without modification. This mechanism is as follows:

(1) All requests will be submitted to the Isotopes Branch, Research Division, Manhattan District, where each request will be reviewed with regard to all technical questions affecting the requester and the Project. This initial review will be made by a group of scientists in the Project who have had much experience in the production of radioisotopes and in technical matters concerned with their use.

(2) Nonproject requests will then be referred to an Advisory Subcommittee on Allocation and Distribution, which has been appointed by Gen. Groves on the nominations of the Distribution Policy Committee. This Subcommittee will have the responsibility of advising on the allocation and distribution of isotopes according to the scientific value of the intended application and the qualifications of the requester. It will operate under the supervision of the Distribution Policy Committee and in conformity with its approved policies. Its members are: K. T. Bainbridge (physics), Harvard University, chairman; J. W. Kennedy (chemistry), Washington University, St. Louis; J. G. Hamilton (biology and medicine), University of California; P. C. Aebersold (biophysics), Manhattan District, secretary.

(3) Each request for material for use in human beings will be referred by the Subcommittee on Allocation and Distribution to a Subcommittee on Human Application, which was similarly nominated and appointed. This Subcommittee will have final veto power on any distribution suggested for human application. Its members, chosen from among radiologists and clinicians experienced in radioisotope uses, are: Andrew H. Dowdy, University of Rochester, chairman; H. L. Friedell, Western Reserve University; G. Failla, Columbia University.

(4) Small Panels of Consultants, nominated by the Policy Committee from a number of specialized fields of possible isotope application and from various regions of the Nation, will be available as advisers on scientific matters connected with requests.

(5) Manhattan Project personnel have not been excluded from membership in any of the nonproject advisory groups. In many cases their membership has been strongly advocated by the Distribution Policy Committee.

(6) Effective liaison will be maintained between the Isotopes Branch of the Manhattan District Research Division, which initially receives and finally effects distribution on nonproject isotope requests, and the associated advisory groups whose functions are set forth above.

Principles of Allocation and Distribution

In establishing initial policies on the distribution of scarce materials, the criterion used has been the maximum benefit to the national welfare, due consideration being given to the limited amount of available material. The initial policies adopted are:

(1) Isotopes will be made available to individuals only through qualified institutions. The administration of the institution will make the necessary financial and legal arrangements, but the material will be allotted for the uses specified in the request.

(2) Secondary distribution of isotopes will not be sanctioned unless indicated and authorized under the original request or subsequently in writing through the accepted channels for requests.

(3) The initial order of priority adopted for the allocation of materials and of production effort is established according to intended use of the material as follows: (a) publishable researches in the fundamental sciences, including human tracer applications requiring relatively small samples; (b) therapeutic, diagnostic, and tracer applications in human beings and publishable researches in the fundamental sciences requiring larger samples; (c) training and education by accredited institutions in the techniques and applications of radioisotopes; and (d) publishable researches in the applied sciences. Allocation of material for researches which are not to be published or for routine commercial applications was considered by the Distribution Policy Committee not to fall within its responsibilities. Allocation for routine commercial

applications will be deferred until experience is gained with supplying the research needs previously mentioned. Special groups may then be established to advise on such allocation.

Production and Distribution Arrangements Within the Project

As indicated in the section on availability, none of the separate purified radioisotopes is in routine operational production. In some cases research groups have progressed only to the point of investigating how irradiations can best be performed to create a given isotope and how to isolate the isotope in small amounts. In other cases methods are under investigation in development groups for increasing the scale of irradiation and chemical processing. In a few cases it has now become possible to start placing irradiations and chemical processing into the hands of technical operations groups for routine "production."

Research into methods of small-scale creation of most of the isotopes took place widely before the establishment of the Project; since then, it has been carried on extensively by project laboratories engaged in nuclear research. Thus, credit for the results of research on radioisotopes is shared by many non-project and project personnel. Most of the research within the Project in this regard has been done by nuclear physics and radiochemistry groups at Clinton Laboratories at Oak Ridge, at the Radiation Laboratory of the University of California, and at the Metallurgical and Argonne Laboratories of the University of Chicago.

The present "experimental-lot production" has been carried on largely by the Clinton Laboratories, which since July 1945 have been administered by the Monsanto Chemical Company. In the case of several isotopes in great demand, the Argonne Laboratory has cooperated in preparing materials in proper form for irradiation at Hanford and in testing the results. The Du Pont Company, operators of the Hanford Plant, has cooperated in making irradiations of materials possible at Hanford. The Monsanto Chemical Company has agreed to initiate the routine production of nationally demanded radioisotopes and to distribute them from the Clinton Laboratories under District Administration.

A Manhattan Project Technical Advisory Committee on Isotopes has been active in maintaining liaison between major laboratories of the Project on (1) production and distribution matters concerned with the national distribution program and (2) developments in radioisotope techniques and applications. This Committee is composed as follows: J. R. Coe, W. E. Cohn, R. McCullough, A. H. Snell, and K. Z. Morgan, of the Clinton Laboratories; W. H. Zinn, W. F. Libby, and R. E. Zirkle, of the Argonne and Metallurgical Laboratories; J. G. Hamilton, B. J. Moyer, and R. E. Connick, of the University of California Radiation Laboratory; J. H. Manley and R. Taschek, of the Los Alamos Scientific Laboratories; and, in regard to concentrated stable isotopes, H. L. Hull and C. E. Larson, of the Tennessee Eastman Corporation, Oak Ridge.

Details of Radioisotope Availability[1]

Pile-produced Radioisotopes

Radioactive isotopes are created in chain-reacting piles by two processes: (1) the fission of U 235 nuclei, which maintains the chain reaction, and (2) neutron absorption by nonfissionable nuclei placed in the pile for the purpose. The former—the so-called "fission products"—exist as a mixture of many radioactive species, each free of significant amounts of stable (carrier) isotopes, in a large amount of the parent substance, uranium. The desired radioisotope must subsequently be separated from uranium and from the other fission products, as well as from any neptunium and plutonium formed by neutron capture in U 238. In the chemical process actually used, the fission products are separated from the mixture either as individual radioactive species or as groups of species (Col. 1, Table 1).

The Fission Products

The methods now in operation for the preparation of fission-product radioisotopes were developed to meet certain definite specifications, which in turn were set by the biological work in which the radioactive materials were to be used. These specifications called for 0.1–1.0 curie[2] amounts of each of the major fission products in carrier-free, essentially solid-free (<10 mg./curie) form, and radiochemically pure (>90–98 per cent, depending on the species); smaller or less pure amounts of minor species were also required. The radiation intensities involved in working with mixtures of fission products at the curie level required the invention and use of chemical processes which were remotely controlled from behind specially constructed lead and concrete barriers and were economical of material. For these reasons the existing processes and equipment are not suited to isolate fission products in forms radically different from those listed. However, since these methods permit the isolation without carrier of nearly every fission product of half-life from 1 week to 30 years and occurring in significant amount, this inflexibility is not considered to be a handicap.

[1] Only those radioisotopes of half-life greater than 12 hours are considered.

[2] The curie is here defined as 3.7×10^{10} disintegrations/second. [See statement by Condon and Curtis, p. 712. Ed.]

Those fission-product radioisotopes which can now be isolated[3] from pile uranium in moderate quantity and good quality without added carrier are listed in Tables 1, 2, and 3. In Table 1 are given also the latest data on half-life and radiation energies for each radioelement involved and also the properties of daughter radioisotopes which will be present. The *temporarily or indefinitely delayed in fulfillment.* The activity stated in this column is related to the figures giving volume and other characteristics of the preparations.

The letters in the column headed "Class" are an attempt to indicate approximate availability and have the following meanings: A: usually on hand (long

TABLE 1*

FISSION PRODUCTS†

Group	Radioisotope	Half-life	Energies β Mev	Energies γ Mev	Radioactive daughters: Isotope	Radioactive daughters: Half-life	Radioactive daughters: Energies β Mev	Radioactive daughters: Energies γ Mev	Probable contaminants	Approx. max. unit quantity which may be made available: Curies	Carrier added: Mg.	Solids present (nonvol.): Mg.	Solvent	Volume: Ml.	Class
I‡	Zr 95	65 d	1.0§ 0.39§	0.73	Cb 95	35 d	0.15	0.75	.....	1	0 ~ 0		½% – $H_2C_2O_4$	50	A
	Cb 95	35 d	0.15	0.75	None										
II	Y 91	57 d	1.8	.....	None				61	1	0 ~ 0		HCl	< 25	A
III‡	Ce 141	28 d	0.6	0.22	None				Pr	1	0 ~ 0		"	"	A
	Ce 144	275 d	0.35	.....	Pr 144	17 m	3.1	.....							
IV	Ba 140	12.8 d	1.05 0.4	0.5	La 140	40 h	1.4, 2.2	1.63‖	Sr	1	0 ~ 0		"	"	B
V‡	Sr 89	53 d	1.5	.....	None				Ba	1	0 ~ 0		"	"	A
	Sr 90	25 y	0.6	.....	Y 90	65 h	2.2	.....							
VI‡	Pr 143	13.8 d	1.0	.....	None				Ce, Y	0.1	0 ~ 0		"	"	B–C
	Nd 147	11 d	0.17 0.85	0.6	61 147	~ 4 y	0.2	.....							
	61 147	~ 4 y	0.2	.....	None										
	Eu 156	15.4 d	0.5 2.5	2	None										
	Eu 155	2–3 y	0.2	0.084	None										
VII	Cs 137	33 y	0.5 0.8	0.75	None				.....	0.01	0 ~ 0				A
VIII‡	Ru 103	42 d	0.2 0.8	0.56					.....	0.1 0.1	0 ~ 0		"	< 25	A–B
	Ru 106	1 y	< 0.005	.....	Rh 106	30 s	3.9	.....							
	Te 127	90 d	0.7	0.086											
	Te 129	32 d	1.8	0.1 0.3 0.8											

* Most data in this table are hitherto unpublished M.E.D. work.
† For I 131, see Tables 3 and 6.
‡ Specific composition depends on age.
§ Two per cent 1.0 Mev and 98 per cent 0.39 Mev.
‖ Complex spectrum.

values in the columns headed *"Approximate maximum unit quantity which may be made available" give essentially the amount which may be supplied at one time; requests for more than this amount may be* half-life permits stock-piling); B: often on hand (shorter half-life does not permit stock-piling); C: seldom on hand; produced on experimental basis only; D: not on hand; can be done but with difficulty.

Inasmuch as a routine production system, with attendant control and standards, does not exist, *no*

[3] It must be emphasized that no routine production system yet exists. The radioisotopes being made available at this time are the results of research and development proceedings.

guarantees of radiochemical or chemical purity or other such characteristic of any entry in any table may be made, although every effort will be made to turn out as high a quality of material as possible. Information relating to the known characteristics of any preparation will be furnished.

To obtain an isotope of this kind involves the insertion of the element, in a suitable form,[4] into the pile and its subsequent removal. Even though in some cases (n,p) radiocontaminants are produced along with the desired (n,γ)-induced radioisotope, no chemical separation process on the active material will be done prior to shipping (hence the term "service irradiation" to describe such an activation). In order to utilize the available facilities most efficiently, these materials will be exposed in the same containers in which they will be shipped, and only certain quantities will be irradiated. Therefore, *those radioelements supplied without processing will be available only in units which are 1, 0.1, 0.01, and (sometimes) 0.001 part of the quantities listed under "Approximate maximum unit quantity which may be made available."*

TABLE 2

FISSION PRODUCTS

(Derived from products in Table 1)

Source (Group in Table 1)	Radio-isotope	Probable radioactive contami-nants	Approx. max. unit quantity which may be made available	Carrier added	Solids present (nonvol.)	Solvent	Volume	Class
			Curies		Mg.			
I	Cb 95	Zr	0.05	0		½% = $H_2C_2O_4$	< 25 ml.	C
VIII	Ru 103 / Ru 106		0.05	0	~ 0	HCl	"	C
VIII	Te 127 / Te 129		0.05	0	~ 0	"	"	C
VI	Pr 143*	Nd, 61	0.02	0	~ 0	"	"	C–D†
VI	Nd 147	Pr, 61	0.02	0	~ 0	"	"	C–D†
VI	61 147	Pr, Nd	10^{-4}	0	~ 0	"	"	C–D†

* See Table 6. † Depends on purity required and age.

Nonfission Radioisotopes

In Tables 4–6 are listed those neutron-induced radioisotopes of half-life greater than 12 hours which are known or believed to be producible in the pile.

(1) *Non-carrier-free radioisotopes; simple* (n,γ) *reactions* (Table 4). The most prominent reaction is simple neutron absorption, yielding a radioactive element isotopic with the parent element. This is the (n,γ) reaction (Table 4), which differs from transmutation and fission reactions in that carrier-free material is *not* produced (except in those few cases where a radioactive chain is begun).

TABLE 3

FISSION PRODUCTS

(By-products usually on hand in impure form)

Radio-isotope	Quantity usually available	Carrier added	Solids (nonvol.)	Solvent	Volume	Class
	Curies	Mg.	Mg.			
Sr 89 / Sr 90 *	1	0	~ 0	N/2 HCl	< 25 ml.	A
I 131†	0.1	0	~ 0	N/10 HNO_3	< 25 ml.	B
Ba 140*	1	> 0	> 0	N/2 HCl	< 25 ml.	B

* See Table 1 for radiation characteristics of isotopes and daughters.
† See Table 6.

(2) *Carrier-free radioisotopes* (Tables 5 and 6). Transmutation reactions yield radioisotopes which differ chemically from their parents and hence exist *without*[5] stable isotopic "carrier." Only a small number of elements are known to undergo (n,p), (n,α), etc. reactions to any appreciable degree in the pile; however, the few which do yield some of the most important radioelements (Table 5). In addition to these types, in which transmutations are effected, there is a group of (n,γ)-induced decay chains which can be utilized to yield carrier-free material (Table 6). In this case a radioisotope produced by a (n,γ) re-

[4] In many cases it is advisable to irradiate elements in the form of a compound. The particular compound selected must be such as to lend itself to irradiation under the expected pile conditions. Undesirable radioactive species and unsatisfactory containers must be avoided. For these and other reasons, the materials to be exposed in the pile for radioisotope production will usually be supplied and packaged by the Project.

[5] Except for impurities below detectable levels.

TABLE 4

LONG-LIVED RADIOACTIVE ISOTOPES PRODUCIBLE IN PILE BY (n,γ) REACTIONS

(Items in italics—Manhattan Project data)

Active isotope	Half-life	Radiation Mev β	Radiation Mev γ	Approx. specific activity (mc./gram element)*	Approx. max. unit quantity which may be made available*	Class
Na 24	14.8 h	1.4	1.4, 2.8	250	100 mc.	A
P 32	14.3 d	1.69		72	500 mc.‖	A
S 35†	87.1 d	*0.17*		1.0	1 mc.‖	D
Cl 36†	*10^6 y*	*0.66*		~ 0.002	10 μc.	D
K 42	12.4 h	3.5	?	20	1 c.	D
Ca 41	8.5 d	K	1.1	0.34	10 mc.	D
Ca 45	180 d	*0.3*		3.8	100 mc.‖	C
Sc 46†	85 d	0.26; 1.5	1.25	125	1 mc.	C
Ti 51	72 d	0.36	1.0	0.13	1 mc.	D
Cr 51	26.5 d	K	*0.32*	70	100 mc.	C
Fe 55	~ 4 y	K		0.07	100 μc.	C
Fe 59	*44 d*	0.26; 0.46	1.1, 1.3	0.15	1 mc.	C
Co 60	5.3 y	0.3	1.1, 1.3	48	100 mc.	B
Ni 59	*15 y*	*0.05* β^+			10 μc.	D
Cu 64	12.8 h	0.58 β^+; 0.66 β^-		440	10 mc.	C
Zn 65	250 d	0.4 β^+; K, e^-	1.14	3.6	100 mc.	D
Zn 69	13.8 h	I.T.; 1.0	0.439	10	100 mc.	D
Ga 72	14.1 h	*3.4*; 0.8	0.84, *2.25*	230	100 mc.	C
Ge 71	11 d	*0.6*	0.5	14	100 mc.	D
Ge 77	12 h	1.9		0.9	10 mc.	D
As 76	26.8 h	1.1, 1.7; 2.7	0.57, *1.25*	770	100 mc.	C
Se 75	*125 d*	K, e^-	*0.18, 0.35*	5.6	100 mc.	D
Br 82	34 h	0.465	0.547, 0.787; 1.35	170	100 mc.	C
Rb 86	19.5 d	1.60		52	100 mc.	D
Sr 89	53 d	1.5		0.2	10 mc.¶	D
Y 90	65 h	2.5		150	100 mc.¶	C
Zr 95‡	*65 d*	1.0, 0.39[z]	*0.73*	0.32	¶	D
Mo 99‡	67 h	1.3	0.24, *0.75*	12	100 mc.	D
Ru 103	*42 d*	0.2, *0.8*	0.56	6.4	10 mc.	D
Ag 108, 110	225 d	*1.3*	0.6, 0.9	10	100 mc.**	D
Cd 115	*2.8 d*	1.11	0.65	33.2	10 mc.	D
Cd 115	*43 d*	1.5		1.6	1 mc.	D
In 114	48 d	I.T., e^-; 2.0	0.19	200	100 mc.	C
Sn 113	< 100 d	K, e^-	0.085	0.26	1 mc.	D
Sb 122	2.8 d	0.81, 1.64	0.8	400	100 mc.	C
Sb 124	60 d	0.74, 2.45	1.72	33		C
Te 127	90 d	I.T., e^-; *0.7*	0.086	0.3	10 mc.¶	C
Te 129	32 d	I.T., e^-; 1.8	0.102; *0.3, 0.8*	0.3		C
Te 131	30 h	I.T. β^-	0.177	0.3		C
Cs 134	2 y	*0.75*	*0.8*	200	1 c.¶ **	C
Ba 131‡	12 d	K, e^-	*1.2* (?)	0.44	10 mc.¶	C
La 140	40 h	1.4, 2.2	1.63§	760	100 mc.¶	D

[z] Two per cent 1.0 Mev and 98 per cent 0.39 Mev particles.

TABLE 4—(*Continued*)

(Items in italics—Manhattan Project data)

Active isotope	Half-life	Radiation Mev β	Radiation Mev γ	Approx. specific activity (mc./gram element)*	Approx. max. unit quantity which may be made available*	Class
Ce 141 ‡	28 d	0.6	0.22	90	100 mc.¶	C
Ce 143 ‡	33 h	*1.36*	*0.5*	22	100 mc.¶	C
Pr 142	19.3 h	2.14	1.9	750	100 mc.**	C
Eu 154	6.5 y	0.9	Present	250	100 mc.	D
Ta 182	97 d	*0.53*	1.22, *1.13*§	300	100 mc.	C
W 185	77 d	0.6	?	10	100 mc.	C
Os 191	32 h	1.5	Present	44	100 mc.	D
Os 193	17 d	0.35	Present	103	100 mc.	D
Ir 192, 194	19 h	2.2	1.35	~ 250	100 mc.	C
	70 d	Present	0.3, 0.4			
Au 198	2.7 d	0.8	0.12, 0.44	6,000	100 mc.**	C
Hg 197	64 h	K, e⁻	0.075	11	100 mc.	D
	25 h	K, e⁻	0.13, 0.16			
Hg 203, 205	51.5 d	*0.3*	0.28	16	100 mc.	D
Tl 206	3.5 y	0.87		2	10 mc.	D
Bi 210‡	5.0 d	1.17		9	10 mc.	C

* May be raised in special circumstances.
† Radioactive contaminant will be present from (n,p) reaction.
‡ Radioactive (nonisotopic) daughter will be present.
§ Complex.
‖ See Table 5.
¶ See Tables 1–3.
** See Table 6.

action decays to a radioactive daughter which is nonisotopic with its parent and with the source material.

A separation of the desired active species from the stable parent and from any (n,γ)-induced radioisotopes of this parent must usually be made before use. Since the parent exists in bulk and there is often formed a large amount of radioactive material which is isotopic with the parent, the processing is not always a simple matter. The same considerations hold in the case of daughters of neutron-induced decay chains.

Again, because of the desire to make available the greatest number of radioisotopes, *such carrier-free species will usually be supplied in the irradiated material, unseparated from the parent and radioisotopes of the parent.* In these cases, as in all others, any

TABLE 5

RADIOACTIVE ISOTOPES FROM TRANSMUTATION REACTIONS

(Items in italics—Manhattan Project data)

Method of formation	Active isotope	Half-life	Radiation Mev β	Target material	Yield mc./gram element irradiated	Conditions for shipment (C.F. = carrier-free)	Approx. max. unit quantity which may be made available	Class
(n,p)	C 14	~ 25,000 y	0.145	$Ca(NO_3)_2$		$BaCO_3$	1 mc.	A
	P 32	14.3 d	1.69	S	0.5*	In S	500 mc.†, ‡	B
						C.F. in 0.1 *N* HCl		B
	S 35	87.1 d	*0.17*	KCl or other chloride	1.5*	In KCl	10 mc.†	B
						C.F.		D
	Ca 45	180 d	*0.3*	Sc_2O_3	0.57*	In Sc	100 μc.†, ‡	C
						C.F. in conc. HCl		C
(n,α)	H 3	~ 31 y	0.015	Li salt		Unavailable at present		

* Experimental data.
† See Table 4.
‡ May be raised in special circumstances.

pertinent experience in a particular separation will be made available. In a few cases, where the element is rare or where the separation is too hazardous to be accomplished without special facilities, only separated material will be supplied.

The symbols in the "Class" column of Tables 4, 5, and 6 have essentially the same meaning as those in Tables 1, 2, and 3 except for "D," which here indicates a reaction which has been reported but has not yet been checked by present personnel.

Pile Irradiation Services for Other Than Radioisotope Production

Materials to be exposed in the pile for radioisotope production will usually be supplied and packaged by the Project. The reasons for this are: (1) to insure that materials and containers introduced into the pile for the desired radioisotope production have minimal parasitic neutron absorption and minimal subsequent radioactivity, and (2) to avoid the possibility of loss of the irradiated material or of danger to the operation of the pile.

Requests for special irradiations, in which the requester desires to furnish the material, may arise because of: (1) other intended purposes than radioisotope production or (2) especially prepared or very rare materials. Such irradiations may require special handling which will be difficult to arrange during the inauguration period of the radioisotope distribution program. When sufficient experience has been gained in handling the normal irradiations and when a scale of charges is determined, special irradiation services may be announced.

Availability of Concentrated Stable Isotopes

In answer to numerous inquiries some brief comments are in order regarding the Project's ability to furnish concentrated stable isotopes. Arrangements have been completed thus far for the production, allocation, and sale of radioisotopes only. It may require considerable time to arrange these matters for such concentrated stable isotopes as may become available in excess of project needs.

The situation in regard to availability is now as follows:

(1) *Deuterium.* There is no heavy water or H_2 available.

(2) *Boron 10.* Small amounts of highly concentrated B 10 may be available for special neutron counter purposes. Prices and distribution mechanism are yet to be determined. These will be announced when arranged.

(3) *Carbon 13.* This isotope is mentioned separately only because of the wide interest in it for tracer purposes, particularly in organic chemistry and biology. There are no project facilities which can at present be converted to concentrate C 13 in production amounts without great expense both in the conversion of equipment and in operation. The cost of C 13 based on operational expenses alone would be considerably higher than costs quoted for C 13 concentrated by chemical exchange methods.

(4) *Isotopes of elements 3 to 82.* Small experimental lots of isotopes of nongaseous elements have been concentrated for project nuclear researches using electromagnetic pilot plant facilities of the Tennessee Eastman Corporation at Oak Ridge.

TABLE 6

Radioactive Isotopes From (n,γ)-produced Chains

(Items in italics—Manhattan Project data)

Active daughter isotope	Half-life	Radiation Mev β	Radiation Mev γ	Target material	Half-life of parent	Yield mc./gram element irradiated	Conditions for shipment	Approx. max. unit quantity which may be made available	Class
As 77	*40 h*	*0.8*		GeO_2	12.0 h	0.9	In GeO_2	1 mc.†	D
Rh 105	36 h	0.5		RuO_2	4.0 h	7.2	In RuO_2	10 mc.	D
Ag 111	7.5 d	0.8		Pd	26 m	9.7	In Pd	10 mc.	C
I 131	8.0 d	0.6	0.367 0.080	Te	30 h	2.5*	In Te C.F. in 0.5 *N* H_2SO_4	100 mc.	B C
Cs 131	*10.2 d*	*K*		$BaCO_2$	*12 d*	~ 0.4*	In $BaCO_3$ C.F. in 0.1 *N* HCl	100 μc.†	B C
Pr 143	13.8 d	1.0		CeO_2	33 h	9.1*	In Ce C.F. in 0.1 *N* HCl	10 mc.†	B C
Au 199	3.3 d	1.01	0.45	Pt	31 m	19.3	In Pt	†	D

* Experimental data. † See Table 4.

Studies have only recently begun on production costs and on the obtainable quality and quantity of concentrated materials. In general, production is quite expensive, and it is difficult to achieve the high isotopic purity desired for many nuclear studies. Arrangements may be formulated for nonproject distribution of experimental lots after more experience has been gained with concentration and assay methods and after project needs become more clear.

As the situation warrants, announcements will be made concerning the availability of concentrated stable isotopes.

Charges

Charges will be made for irradiated materials and processed isotopes, as is the case for many widely useful products resulting from other research efforts. Pending experience, a reasonable charge is considered to be one based on the "out-of-pocket" operational expenses necessitated by the nonproject production and service program. Charges will not include costs of rental, or construction of plant and major facilities or of research and development directed toward the supplying of isotopes in general. The Project will supply the major facilities and develop the production methods, but will assess a charge for the additional running expenses of man power and materials incurred by the filling of nonproject requests. Shipping expenses will be paid by the requester. Details of these arrangements and the prices to be charged may be obtained upon request from the Isotopes Branch of the Manhattan District Research Division.

Mechanism for Making Requests

As explained in the section on "Principles of Allocation and Distribution," radioactive materials will not initially be distributed directly to private individuals but only to accredited institutions or organizations. However, materials will be allocated to an individual or a department for the specific uses proposed in the request.

A request may be initiated by a responsible applicant in an accredited institution by a short letter to the Isotopes Branch, Research Division, Manhattan District, P. O. Box E, Oak Ridge, Tennessee. This letter should request application forms, price quotations, and any essential information not contained in this notice. It should indicate briefly the radioisotopes desired, the approximate quantities needed, and the use to be made of the materials. If the desired material can be produced or made available and the intended use is one for which the isotope is suited, application forms will be furnished the applicant. These forms will permit applicants to supply in a concise and uniform manner the necessary detailed information on the basis of which the reviewers and the nonproject Advisory Subcommittee on Allocation and Distribution will be able to recommend action.

Action on an initial formal application cannot be initiated unless it has been indicated on the application that, when material is allotted, an "Agreement for Order and Receipt of Radioactive Materials" will be negotiated by the business administration of the requesting institution. This agreement relates to business and legal responsibilities in connection with the ordering, receipt, application, and disposal of radioactive materials by the applicant. The honoring of subsequent applications from the same individual or department can be arranged on a continuing basis by the indication of authorization for this in the originally negotiated agreement. All correspondence concerning requests and all forms should be addressed to the Isotopes Branch, as indicated above.

A Nuclear Research Institute at Oak Ridge

The Executive Committee, Oak Ridge Institute of Nuclear Studies

THE INTERNATIONAL SIGNIFICANCE of atomic energy as a military weapon and its potential peacetime uses have been in the forefront of public discussion for some time and have overshadowed other problems relating to the future of atomic energy developments. One problem that is receiving much attention in scientific circles today concerns the best procedure for ensuring the continuance and further development of broad fundamental research in the field of nuclear studies.

While there are differences as to procedure, the consensus appears to be that the broad national interest can best be served through the establishment of research centers for nuclear studies in several parts of the country. Established research groups in universities, government agencies, or industry can then cooperate with these centers in carrying on atomic research in physics, chemistry, biology, medicine, and engineering. It is well recognized that the cost of nuclear research is such that few, if any, of the established private research agencies, working alone, will be in a position to make substantial contributions to this field.

The position of Oak Ridge as a possible location for one of these centers appears to be unique, both because of the elaborate facilities already built and in operation there and because of the presence of a large and active research group in the Clinton Lab-

oratories already effectively engaged in such research. In view of this situation, a group of southeastern universities is sponsoring a plan looking toward the establishment of an Oak Ridge Institute of Nuclear Studies, where research at the Ph.D. level and above would be carried out in the fields of physics, chemistry, biology, medicine, and engineering. The establishment of such an institute will provide the formal channels for cooperative research between the universities and governmental research and producing agencies associated with the atomic energy project at Oak Ridge.

Although the initial sponsorship of this Institute has been confined to southeastern universities, other universities outside the region are now participating in its development. It is contemplated that a number of institutions throughout the United States will share in this cooperation, even though they are looking forward to the establishment of new research centers, similar to Oak Ridge, in the section of the country in which they are located.

The early establishment of such a cooperative Institute at Oak Ridge will have a number of important advantages in terms of the national interest in the development of atomic energy. Among these may be cited the following:

(1) The development of the Institute around the already existing research and production facilities at Oak Ridge can be accomplished with a minimum of delay so that cooperative research with universities can go forward actively at an early date. It will, obviously, be at least one to two years before the necessary organizational plans, design, and construction of facilities can be completed for the establishment of new centers for such cooperative research in other parts of the country.

(2) The cooperative Institute at Oak Ridge will serve as a prototype for the establishment of similar centers in other parts of the country. In the interim before the establishment of such other centers, research workers from universities in various parts of the country can be initiating research programs relating to nuclear studies, which otherwise would have to be delayed from one to three years.

(3) Two large isotope separation plants are being operated at Oak Ridge for the large-scale production of U 235 in addition to the research program being conducted at the Clinton Laboratories. Although these units are primarily industrial, the proximity of the large and active research group at the proposed Institute will be of great value in ensuring the vigorous development of these methods and in attracting and holding competent technical personnel for them.

(4) The location of a nuclear research center in the southeastern region is clearly important to the national interest. The recruiting of potential man power for work in this field has in the past been neglected except in limited regions of the country, notably the Northeast and the far West. With the location of a large and progressive research establishment in the Southeast, young men who otherwise would not be attracted to scientific work of this type will become interested.

(5) It is apparent that such research centers, wherever they are located, will have to be organized as geographically independent entities, and it will not, in general, be possible to locate them in close proximity to already existing educational or governmental institutions. The availability of an adequate amount of Government-owned land and the Government's existing large investment in facilities at Oak Ridge point toward this as one of the logical locations for the establishment of such a research center. In order to implement the establishment of such a cooperative Institute effectively, it will be necessary only to group and allocate properly such expanded research facilities as are contemplated at Oak Ridge in a common area where they can serve as the nucleus for the development of a future Institute. It is hoped that planning for the extension of research facilities at Oak Ridge will be done in such a way that these facilities can be brought together in a common area which would be appropriate for the future development of an Institute.

The national stake in the future of atomic energy is a vital one, and any steps that will assure that active research is not interrupted are of the utmost importance at this time. The effectiveness of such research depends on continued cooperation between private agencies, such as the universities and industry, and the Government. It therefore seems imperative that advantage be taken of the opportunity existing at Oak Ridge, with its established facilities and personnel, to develop immediately such cooperative research through the organization of an Institute for advanced nuclear studies.

Technical Papers

Interpretation of Resistance to Fusarium Wilt in Tomato

WILLIAM C. SNYDER, KENNETH F. BAKER, and H. N. HANSEN
Division of Plant Pathology
University of California, Berkeley and Los Angeles

It has been established (*6*) that the Pan America tomato is highly, but not completely resistant to the Fusarium wilt disease, caused by *F. oxysporum* f. *lycopersici* Snyder and Hansen, under conditions fatal to the susceptible variety, Bonnie Best. In endeavoring to determine the nature of this resistance Fisher (*2*), and more recently Gottlieb (*3*), and Irving, Fontaine, and Doolittle (*5*) have given evidence that the expressed sap from resistant Pan America plants is inhibitory to the growth of the pathogen *in vitro* when compared to that from susceptible Bonnie Best plants. Heinze and Andrus (*4*) have concluded from their study of reciprocal grafts of these two varieties that "resistance to the wilt fungus in tomatoes appears to be localized entirely in the root systems of the resistant varieties and is not transportable." This implies that the tops of Pan America are susceptible. However, only infection through roots was considered, and no evidence was presented on susceptibility or resistance of tops. Moreover, the work of Irving, *et al.* and Gottlieb indicates that the substance responsible for resistance is found in all parts of the plant.

The writers have approached this question with still a different technique. Our results, added to what has already been done on the subject, seem to justify the following conclusions: First, resistance is not localized in the root system. Second, the substance responsible for the resistance is not present in inhibitory amounts in the xylem stream. Third, resistance originates in the living tissues of the plant, and the material causing resistance does not migrate or diffuse into the xylem vessels. Fourth, field resistance to infection functions in living cells of the roots through which the fungus, a soil organism, must pass to become a vascular pathogen.

Bonnie Best and Pan America plants were grown in sterilized soil and inoculated when six weeks old by cutting through the lower taproot under a spore suspension of the fungus. The roots were washed and the plants repotted singly in six-inch pots in the greenhouse. In every case the fungus spores began growth in the vascular elements of the root into which they had been drawn when the root was cut, and the mycelium developed upward through the root into the above-ground stem, producing therein vascular discoloration. The discoloration extended higher in the stems of Bonnie Best than in those of Pan America. Foliage symptoms appeared on Bonnie Best rapidly under these conditions, but only a few individuals of Pan America showed disease symptoms. The failure of symptoms to appear in all Pan America plants containing the fungus in the xylem of the stem indicates the presence of resistance in the stem as well as the roots.

The presence of the fungus in the xylem was demonstrated by cultures, and by microscopic examination of stained sections it was shown to have developed in the vascular elements of Pan America about as robustly and abundantly per infected element as in Bonnie Best. Therefore, if there were any fungus inhibitor present in the tracheal fluid of the Pan America plants, it must have been negligible in its effect. The number of vessels infected in Pan America was much lower than in Bonnie Best (perhaps owing to the inoculation method), and this fact may explain in part why the former shows symptoms slowly, if at all, even though the fungus be present in root and above-ground stem. An explanation for this phenomenon may lie in multiple infection of the xylem elements of Bonnie Best following surface contamination of lateral roots during inoculation, whereas infection of Pan America by this technique allows invasion only of those elements into which the spores actually were drawn. If this interpretation is correct, the wilt symptoms obtained in Bonnie Best, but not in invaded Pan America plants, are an expression of fungus mass action in toxin formation.

The comparable robust growth of the fungus *in vivo* in the infected vascular elements of both varieties of plants also argues against a mobile fungus inhibitor in one of them. In the resistant plant, growth of the fungus in the xylem shows that resistance is not a property of the entire root system.

Additional evidence that an inhibitory substance is lacking in xylem fluid was shown by the comparable growth of the fungus *in vitro* in such liquid obtained from resistant as well as susceptible plants. The fluid forced by root pressure from the cut ends of plants truncated at the soil level was used for this test. It appears, therefore, that xylem fluid is noninhibitory to the fungus *in vivo* and *in vitro*. This would indicate the absence or high dilution of the resistant factor therein.

If disease resistance in Pan America is physiological in nature, conceivably it may consist of resistance to invasion, resistance to yellowing and wilting, or to both. The former, which is under consideration in this paper, is concerned with the entrance of the fungus into the xylem; the latter, with production of toxins in the tissue.

If it is true that under natural conditions favorable for the disease *F. oxysporum* f. *lycopersici* enters the susceptible plant through the undifferentiated tissue just back of the root tip and that the resistant plant does not become invaded, at least not to the extent that vascular elements are entered, the above observations would indicate that resistance is a quality of the living cells only of the Pan America plant. It is this quality which appears to bar the fungus from the lumen of the xylem tubes.

It may be concluded from all evidence so far presented that resistance here in the Pan America tomato to invasion by the wilt Fusarium is a direct function of the cellular protoplasm of the plant similar to that of cabbage (*1, 7*). Apparently it is present but not localized in the root system, and does not operate in the xylem.

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The Blood Parasites of the Blue Grouse

C. David Fowle

Department of Zoology, University of Toronto

In a recent paper Herman (*1*) listed the avian blood protozoa of North America and indicated the hosts in which they had been found. In view of the fact that the blue grouse (*Dendragapus obscurus*) is not included in his host list it would seem to be of value to record a few observations made recently upon the blood of this species.

Blood samples were collected during the summers of 1943 and 1944 from 44 specimens of blue grouse (Subspecies: *Dendragapus o. fuliginosus*) taken on Vancouver Island, British Columbia. In 1943 smears were made from 28 birds taken at Campbell River during June, July, and August. Four more were made in August of the following year. One smear was made from a bird collected at Cowichan Lake in 1943 and from 11 additional specimens collected from the same vicinity during September 1944.

Four blood parasites, namely, *Trypanosoma, Haemoproteus, Leucocytozoon,* and *Microfilaria,* were observed in smears after they had been stained in Giemsa. The incidence of infection with these parasites is shown in Table 1.

The incidence of infection was higher in Campbell River birds examined in 1943 (see Table 2) than in the combined sample from Campbell River and Cowichan Lake (see Table 1).

TABLE 1

Incidence of Parasites in Per Cent
(Campbell River and Cowichan Lake, 1943 and 1944)

No. of birds	44 Whole sample	23 Adults	21 Juveniles
Trypanosoma	5	4	5
Haemoproteus	52	57	48
Leucocytozoon	18	22	14
Microfilaria	12	22	..
Negative	41	43	38

In Table 2 it will be noted that while the incidence of infection among juveniles approximates that shown in Table 1 the figures for adults are considerably higher. Unfortunately, no comparison can be made

TABLE 2

Incidence of Parasites in Per Cent
(Campbell River Only, June, July, August, 1943)

No. of birds	28 Whole sample	12 Adults	16 Juveniles
Trypanosoma	7	10	6
Haemoproteus	64	83	50
Leucocytozoon	29	42	19
Microfilaria	15	40	..
Negative	25	17	31

between the two collecting stations because there is insufficient material from Cowichan Lake for 1943.

The degree of infection observed for these four parasites varied, but in no case were they very great. Trypanosomes were found in extremely small numbers in only two birds. *Leucocytozoon* seldom exceeded two parasites per thousand blood cells. In the case of *Haemoproteus,* the commonest and most numerous form noted, the infection in adults at Campbell River averaged 12 parasites per thousand cells during the months of June, July, and August. Infections ranging from 1 to 27 organisms per thousand erythrocytes were noted. The figures for juvenile birds collected during the same period were, on the average, somewhat lower. All birds collected at Cowichan Lake during September 1944 showed light infections ranging around two to three organisms per thousand cells. Moreover, 7 out of 10 smears collected

this time were negative. This may indicate that e degree of infection decreases at the end of the mmer. A definite statement cannot be made, however, since the degree of infection during September 44 at Campbell River is not known and no comrison can be made.

Microfilariae were found in the blood of 22 per nt of the adults but were not observed in any of e juveniles. In no case were they very numerous. his does not mean, however, that the young birds ere not infected. It is possible that the adult paraites were present but had not reached maturity in e solid tissues. Consequently, the young stages ould not have appeared in the blood.

Mixed infections were found in 7 birds as follows:

	Per cent
Haemoproteus, Leucocytozoon, Trypanosoma ...	1 bird 2
Haemoproteus, Leucocytozoon, Microfilaria	3 birds 7
Haemoproteus, Trypanosoma	1 bird 2
Haemoproteus, Microfilaria	2 birds 4.5

Few data as to the mode of transmission of these parasites were obtained. Louse-flies (*Diptera, Hippoboscidae*) of unknown species were noted on 4 out of 53 birds (7.5 per cent) collected at Campbell River in 1943. However, no adequate study was made to prove that these were the transmitting agents. In any case, they do not appear to be numerous enough to account for the high percentage of infected birds in the population.

None of the birds examined appeared to be suffering any ill effects from infections by any of these parasites.

(I am indebted to Dr. A. M. Fallis, of the Ontario Research Foundation, for assistance in the preparation of this note.)

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The Relative Effectiveness of Pure Penicillins G, X, and K

ROBERT D. COGHILL, A. E. OSTERBERG, and G. R. HAZEL
Abbott Laboratories, North Chicago, Illinois

In connection with the study of a new penicillin prepared in this laboratory it was noted that the blood levels resulting from its injection were of a shorter duration than those obtained under the same conditions from a commercial penicillin. Because this new penicillin (No. 128) had an activity of 3,500 units/mg. as compared with 2,300, 1,667, and 900 units/mg. for penicillins K, G, and X, respectively, consideration was given to the possibility that it was being excreted faster than the others. This might follow when one considers that it takes approximately four times as many molecules of penicillin X as it does of the new penicillin to give dosages which are equivalent in terms of International Units.

Accordingly, an experiment was set up to determine whether the rate of excretion of a pure penicillin is a function of its potency in terms of units/mg., or, in other words, of the number of molecules injected. The penicillins used were analytically pure preparations of the crystalline compounds. These had been subjected previously to extensive chromatographic treatment to insure their separation from other penicillins. They were dissolved in normal saline at a concentration of 5,000 units/ml.

Each penicillin, on different days, was injected into each of the same four subjects. Twenty-five thousand units were injected intravenously into one arm, and blood samples withdrawn from the other arm at suitable intervals. Urinary excretion of the penicillins was measured at half-hourly intervals during the first two hours and hourly thereafter. The urine was assayed[1] by the usual cylinder[2]-plate method against *Staphylococcus aureus* 209P, and the blood levels were determined by the method of Heilman (*1*) against her strain of a hemolytic streptococcus. A penicillin G standard was used in each case.

The duration of penicillin blood levels of at least 0.03 unit/ml. for each of the penicillins was as follows: penicillin G, 2–2.5 hours; penicillin 128, 1–1.25 hours; penicillin K, .5–.75 hour; and penicillin X, 4–4.5 hours. Even though the figure for penicillin X is somewhat exaggerated because the test organism is approximately eight times as sensitive to this penicillin as it is to the standard penicillin G,[3] the blood levels do not fall in the same order as the activities as expressed in units/mg.

The explanation for the poor action of penicillin K is apparent when one examines the excretion figures. These indicate that during the first two hours, the various penicillins are excreted in the following percentages: penicillin G, 83; penicillin 128, 58; penicillin K, 28; and penicillin X, 78. Penicillins G and X were excreted in the amount of approximately 80 per cent, the difference between them being within experimental error. Penicillin K, however, was excreted to the extent of only about 30 per cent. Since very little penicillin is excreted after the second hour,

[1] The authors are indebted to H. W. Cromwell and his staff for all assays reported in this paper, and to F. H. Stodola, of the Northern Regional Research Laboratory, for his gift of the necessary penicillin X.
[2] Paper discs were used rather than cylinders.
[3] This was determined for each of the penicillins on the original solutions containing 5,000 units/ml. Penicillin X prevented hemolysis at eight times the dilution, and penicillins K and 128 at the same dilution, as did penicillin G.

this can only mean that penicillin K is very rapidly destroyed in the body—so rapidly that its therapeutic effectiveness must be very small indeed. These excretion figures also indicate the incorrectness of the original premise which formed the basis of the experiments. It would appear that, in the dosage used, penicillins G and X are excreted at about the same rate, even though twice as many molecules of X were used, and that the rate of excretion of penicillin K is obscured by its high rate of inactivation. At the very low concentrations in which penicillin occurs in the blood it is apparently almost completely removed in one passage through the kidneys.

A check experiment was made with a recent commercial lot of penicillin. Chromatographic examination and corollary checks (including crystallization of its penicillin G) showed this lot to contain approximately 92 per cent of G and 8 per cent of K. Examination of the blood levels and excretion data indicates that this commercial penicillin behaved in every way as did the pure penicillin G—that is, with experimental error.

Conclusions

On the basis of this admittedly preliminary and meager experimental evidence, one would be justified in concluding that (1) penicillin K is so unstable in the human that its therapeutic usefulness when used parenterally is open to very serious question; (2) penicillins G and X are sufficiently stable that their excretion by the kidney represents the limiting factor in the maintenance of therapeutic blood levels; and (3) penicillin X is sufficiently more active (on an International Unit basis) against at least one strain of a hemolytic streptococcus that its use would be indicated for an infection caused by any organism of similar sensitivity.

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News and Notes

George Briggs Collins, professor of physics at the University of Notre Dame, has been appointed head of the Department of Physics at the University of Rochester. Dr. Collins, who will begin his new duties with the fall semester in September 1946, succeeds Lee A. DuBridge, head of the Rochester Physics Department for the last 12 years, who has resigned to become president of California Institute of Technology. Dr. DuBridge, as director of the Radiation Laboratory, was closely associated with Dr. Collins at M.I.T. during the war.

Paul Willard Merrill, of the staff of the Mt. Wilson Observatory, was awarded the Henry Draper medal by the National Academy of Sciences on 23 April for his numerous important contributions, particularly those on stellar spectroscopy.

David Glick has been appointed associate professor of physiological chemistry at the University of Minnesota and consultant in biochemistry to the Veterans' Hospital, Minneapolis. His appointment was effective 1 April 1946.

Frank B. Jewett, president, National Academy of Sciences, delivered a lecture on 10 May before the Sigma Xi Chapter of North Carolina State College. Dr. Jewett spoke on "The Future of Scientific Research in the Postwar World."

Kazimierz Sembrat, Instytut Zoologiczny Uniwersytetu, Wroctaw, Poland, lost all of his academic literature during the war and suffered severe physical injuries from bombings. He is greatly in need of reprints and textbooks in zoology, particularly in the field of experimental embryology. Dr. Sembrat was a Rockefeller fellow at the University of Chicago, Yale University, and the Marine Biological Laboratory at Woods Hole during 1936–37.

Ernest H. Volwiler, executive vice-president of Abbott Laboratories, was granted a D.Sc. degree at Miami University, Ohio, on 2 June. Dr. Volwiler has been a member of the board of directors of Abbott Laboratories, Chicago, and director of research since 1930. He was elected vice-president in charge of research and development in 1933, and became executive vice-president of the Laboratories last March.

John R. Ball, professor of geology and paleontology at Northwestern University and for 30 years a member of the staff, will retire at the end of the current academic year but expects to continue active geologic work.

Alpheus W. Smith, physicist and retiring dean of Ohio State University Graduate School, was awarded an LL.D. at the Ohio State commencement exercises on 7 June.

William C. Krumbein, Gulf Research and Development Company, has accepted an appointment as professor of geology at Northwestern University, effective September. Dr. Krumbein will participate in development of geological work in the Northwestern Technological Institute, as well as in the teaching program.

Announcements

A Defense Research Laboratory for study in the fields of aeronautics, electronics, chemistry, optics, thermodynamics, acoustics, and mathematics has recently been established at the University of Texas. This organization is one of a series in universities and in industry operating under a Section-T contract with the Bureau of Ordnance. The research goal of the Laboratory, sought through the above fields of study, consists of fundamental problems relating to certain forms of guided missiles.

Dr. C. P. Boner, professor of physics at the University, has been on leave of absence as associate director of the Underwater Sound Laboratory of Harvard University, is the director of the Defense Research Laboratory. Dr. M. J. Thompson, until recently group supervisor for aeronautics at the Applied Physics Laboratory of The Johns Hopkins University, is associate director. The research staff includes members of the University academic staff from the College of Engineering and the Departments of Physics, Chemistry, and Mathematics. This group is augmented by additional full-time research staff members who are being recruited from other laboratories engaged in similar research. The staff numbers approximately 75 people, among them R. C. Anderson, M. L. Begeman, C. P. Boner, H. J. Ettlinger, B. E. Short, M. J. Thompson, and R. B. Watson, all members of the AAAS.

The Michigan College of Mining and Technology announces that the following have returned to its faculty: Chester Russell, associate professor of electrical engineering, from industry; J. H. Service and H. W. Risteen, associate professors of physics and mechanical engineering, respectively, both from the Navy; M. W. Bredekamp, assistant professor of chemical engineering, from the Oak Ridge project; V. W. Johnson, forestry; and Ernest Kemp, geology. Instructors added to the staff are: Clarence Bjork, George Brooks, Lester Dawson, and Harry Winter, mathematics; C. M. Harry, mining engineering; and Thomas Coon, mechanical drawing.

The Lasker Award, presented annually for outstanding service in the field of mental hygiene, will be given this year for the most significant experimental investigation into behavior deviation, it was announced recently by George S. Stevenson, medical director of the National Committee for Mental Hygiene.

Nominations with supporting data, which will be presented to an anonymous jury chosen for its competence to judge accomplishment in the field selected, are now being accepted by the Committee. The work of the candidate must either have been accomplished or have been tested and won general acceptance approximately within the past year. Presentation of the $1,000 award is made each fall at the annual meeting of the Committee, which will be held this year on 30–31 October at the Hotel Pennsylvania. The Lasker Award was established in 1944 by the Albert and Mary Lasker Foundation. Col. William C. Menninger won the award in 1944, and John Rawlings Rees, consultant in psychiatry to the Directorate of Psychiatry of the British Army; and Maj. Gen. G. Brock Chisholm, Deputy Minister of National Health, Federal Department of National Health and Welfare, Canada, received the award jointly in 1945 for outstanding service in rehabilitation.

Plans for construction of a sulfuric acid plant on the James River between Bellwood Road and Kingsland Creek in Bellwood, nine miles southwest of Richmond, Virginia, have been approved by E. I. du Pont de Nemours and Company. The plant, which will be operated by the Grasselli Chemicals Department, will cost approximately $1,500,000. It will be located on a 425-acre site recently purchased by Du Pont and will produce sulfuric acid for local consumers who previously relied on supplies shipped into the area.

Harvard University announces that Gordon M. Fair has been appointed dean of the Graduate School of Engineering, effective 1 July.

Meetings

The Pacific Division of the AAAS will hold its 27th annual meeting at the University of Nevada, Reno, 17–22 June. The following program has been scheduled:

Tuesday morning—A symposium on "Antibiosis," with Thomas L. Jacobs, University of California at Los Angeles; David Bonner and Lowell A. Rantz, Stanford University; and K. S. Pilcher, Cutter Laboratories, Berkeley, California, participating; *Tuesday afternoon,* 4:00–6:00 P. M.—A general reception on the University campus for members of the Association and associated societies and their guests, given by the president of the University, John O. Moseley, and Mrs. Moseley; *Tuesday evening*—A lecture on

"Research in the Social Sciences," by Holbrook Working, Stanford University; *Wednesday evening*—The presidential address on "The Influence of Molecular Structure on Biological Activity," by Linus Pauling, president of the Pacific Division; and *Thursday evening*—A lecture on "Fundamental Particles and Atomic Energy," by Wendell M. Latimer, University of California.

A conference on algebra will be held at the University of Chicago during the week of 15–19 July. Some of the sessions will emphasize the recent contacts of algebra with other branches of mathematics such as topology, function theory, and geometry. It is hoped that the meetings will be held in Eckhart Hall. Reservations should be made directly with Chicago hotels. Hotels in the vicinity of the University of Chicago are the Broadview, 5540 South Hyde Park Boulevard; Del Prado, 5307 South Hyde Park Boulevard; Shoreland, 5454 South Shore Drive; Windermere, 1642 East 56th Street; Mira-Mar, 6218 South Woodlawn. Because of the acute shortage of hotel space, reservations should be made as soon as possible.

New Units for the Measurement of Radioactivity

It has become the custom to express the strength of radioactive sources in terms of curies. This is an erroneous use of this unit, since by original definition the curie is that "amount of radon in equilibrium with one gram of radium" (Rutherford's *Radioactive substances and their radioactivity,* 1913, p. 479; The radioactive constants as of 1930. *Rev. mod. Phys.,* 1931, **3**, 427), as defined by the Radiology Congress in Brussels in 1910. Therefore, the curie can be used only to represent a rate of disintegration in the radium family. It then represents the disintegration rate of radium or its products in equilibrium. Such a use has been endorsed by the International Radium Commission.

The quantity to be specified in designating the strength of radioactive sources in general is the disintegration rate, determined by the decay constant and the number of atoms of the radioactive isotope in the source. This is simply a number, and therefore, to establish a suitable unit, the only requirement is to select a convenient number of disintegrations per second and give it a name. In selecting this number consideration should be given to insure that it can be readily expressed in submultiples, and multiples by the usual prefixes, kilo-, milli-, micro-, etc. A number which fits this requirement is 10^6. Since the curie was named in the honor of M. and Mme. Curie, the co-discovers of radium, it is natural to select the name "rutherford" for the new unit. The appropriate abbreviation is "rd," which conflicts with the abbreviation of no other well-accepted physical unit. The micro-rutherford would become one disintegration per second—a convenient number to remember. Furthermore, the rutherford itself is a small unit of the order of magnitude of many sources used in laboratory measurements. It is sufficiently different in size from the curie that no confusion can arise with the curie in connection with measurements of activities in the radium family. Large sources would require the use of positive powers of 10, which would be preferable to the use of a large unit requiring negative powers of 10.

It should be pointed out not only that continued use of the curie for all radioisotopes requires a redefinition of the curie, but also that the value of the curie is uncertain to at least 4 per cent and values in current use are well outside this limit. The rutherford provides a definite unit. In addition to eliminating the undesirable use of the curie, the proposed unit also eliminates the basic necessity for measuring radioisotopes in terms of a standard. Any measuring device which will determine the total number of disintegrations per second will provide directly the strength of the source in rutherfords. A counting arrangement for which the solid angle factor is known is an example. Radioactive standards may be used to determine this factor for a given geometrical arrangement, but other methods are also available.

In the measurement of sources of gamma rays the roentgen has gained increasing use, largely because this unit is independent of the quality (electron volts) of the gamma radiation. There is need for a unit in which the intensity of gamma ray sources can be expressed to eliminate the use of the curie for this purpose. An obvious unit derived from the definition of the roentgen is a roentgen-per-hour at one meter. The roentgen-per-hour at one meter can be abbreviated to r.h.m., which again is not readily confused with any other common abbreviation. It has been suggested that this abbreviation can be pronounced "rum." It should be noted that a gamma ray source equal to one r.h.m. will have a gamma ray strength 1.18 times that of one curie of radium. Therefore, the roentgen-per-hour at one meter has the same order of magnitude as the curie in the measurement of gamma ray sources.

The National Bureau of Standards, at the suggestion of the Committee on Radioactivity of the National Research Council, recommends the general use of these units.—*E. U. Condon* and *L. F. Curtiss* (National Bureau of Standards).

Letters to the Editor

Concerning Rains of Fishes

At the risk of seeming a very obdurate Sadducee I am afraid that I must persist in my incredulity concerning rains of fishes (*Science*, 1946, **103**, 693). That many people have professed to believe in rains of fishes I am well aware. That many people have observed fish on the ground after a heavy rain may be. But no trained observer has yet seen quantities of fish coming down out of the sky.

Dr. Gudger says that these remarkable downfalls have been "scientifically attested." But what does he mean by this? He refers to "scientific men of high standing and veracity" who "did not witness the falls" yet professed to believe in them. But profession of belief does not in itself constitute evidence, however honored the professor. *No* man's "printed word" is "accepted today by scientific men" as conclusive proof of anything. It is the very essence of science that it should not be.

Dr. Gudger's evidence is all hearsay, and that often at second and third hand. His fullest account is James Prinsep's account of a Mr. Cameron's communication of the alleged depositions of some Indian farmers. Two of these witnesses state that some of the fish were "stinking and headless," and the one who gave the fullest account said that after the fish had struck him on the head he "looked at heaven" and "saw like a flock of birds flying up." The correspondent from Louisiana only states in effect that some fish had been found in boats that had been swamped in a high wind. What more likely?

The very nature of waterspouts, unfortunately, renders exact observation of them almost impossible, and hence little is really known about them. But such accounts as there are (as, for example, in Wenstrom's *Weather*. Boston: Houghton-Mifflin, 1942. Pp. 323–328) suggest that the cone is composed of spray or mist *drawn down from the cloud* and that such water as is drawn up from the surface of the ocean or lake or river by the vacuum—the only part that might possibly carry fish—would not be carried far across the land and could not possibly be mistaken for rain. Milman, in his *Meteorology* (New York: Macmillan, 1929. P. 342), says that "stories of large quantities of water being carried up from the sea into the clouds is pure myth."

BERGEN EVANS

Northwestern University

Why Is Taxonomy Ill-supported?

Fosberg and Diehl, in "Present status of foreign herbaria and museums" (*Science*, 1946, **103**, 282), make several observations which are important to biological science and with which most botanists will heartily agree. I wish to comment on only one phase of the problem, mentioned by them in these words: "Systematic botany has traditionally been ill-supported." This is true, and it will continue to be true, and deservedly so, as long as taxonomists maintain present principles and practices. Taxonomy is the only branch of science where this is true.

Rewards are bestowed, in taxonomy, for creating names and not for knowledge of the organism named. Some persons have renamed scores, hundreds, and probably even thousands of plants which they never saw and could not possibly recognize if they did see them, but the names so applied must be acknowledged under taxonomic rules, either as valid or as synonyms. No stigma or penalty whatsoever is attached to the creation of innumerable synonyms.

Permanent rights are accorded to the creator of a name, without regard for the general welfare of scientists. This is true whether the name be valid or one of the many kinds of synonyms; whether it was based on knowledge or ignorance; whether it represented an addition to, or merely confusion of, the existing knowledge; and wholly without regard to the inconvenience caused to tens of thousands of other workers. When a man wishes to patent an idea, under United States law, he must submit it to a jury of experts (U. S. Patent Office). If they determine that it is sufficiently new and different to warrant recognition (patent), he has to pay a sum of money to obtain such recognition. After all that, he gets exclusive rights for only 17 years—not forever.

Taxonomy has no required standards of preparation or fitness, yet its products may help or harm many. Anyone who wishes may name organisms, and the names must be recognized forever, either as valid or as synonyms. Schoolteachers must be trained and must pass examinations in order to teach even the three R's in the rural schools. Auto drivers, electricians, plumbers, and public accountants must be examined by experts and must obtain a license before they may operate. Dentists, doctors, lawyers, and ministers must be examined and certified before they can ply their trades. But anyone may apply Latin names to organisms, and the names automatically have permanent status in one or the other of two categories. The products of an ignorant, careless, or dishonest tyro may cause untold and continuing labor to many others much more able.

Taxonomy is the only science that openly appeals to, and openly rewards, the innate selfishness of man by guaranteeing the permanent association of his name with the organism-name he coined, whether it be of value or not. Chemists, physicists, geologists, mathematicians, physicians, and philosophers make discoveries and develop theories of immense importance to humanity, but we are under no compulsion to attach their names when referring to such discoveries and theories. Sometimes we do, in the case of a dozen out of tens of thousands (Boyle, Darwin, Einstein, LaPlace, Newton), but no rule compels it. What is the value of a single plant

name, out of a million or more, as compared with one of these great products of the human mind?

These principles and practices of taxonomy have created another field of labor, synonymy, fully as difficult, more far-reaching, and even more expensive, as taxonomy, and we are but at the beginning. Some now devote their time to the study of names and never learn about plants. All real taxonomists are compelled to spend an increasing percentage of their time in the study of names, leaving less and less of their energy for the study of plants. Which are the most important to humanity, names or plants? Which are the most important to science?

All of this has been done under a fetish known as stabilizing nomenclature. Fosberg and Diehl refer to systematic botany's contribution in studies to "stabilize nomenclature." I will defy any person to compare the successive manuals of botany issued in the last 100 years and produce any indication whatsoever that nomenclature is being stabilized. If the permanence of patent (priority) rights to a name never had been acknowledged in taxonomy, we would have had a stable nomenclature long since. As it is, all workers in botany have to learn a new set of names for most plants every 25 or 30 years. This not only is maddening, but absolutely unnecessary.

Suppose that we applied such a rule in the realms of chemistry, economics, geology, cosmogony, mathematics, philosophy, physiology, theology, etc., and had to cite the name of the original promulgator of an idea every time we mentioned it. Suppose that we always were finding (as we are) that someone just a little earlier had evolved what might be claimed to be the same idea. Suppose that we had to append the name of the architect or builder every time we mentioned a great structure or addressed a letter to a given house or office building. If we did, we would be approaching the futility of the situation to which the stupidity and unrealism of taxonomists have brought that science.

If the taxonomic world really believed in, or desired, stability of nomenclature, they would have worked to achieve it long ago through limiting prior rights to a specified term of years or through conserving well-known and widely used specific names when they had been in such use for 100, 50, or 25 years. This would prevent the present disastrous absurdity of letting a few-months priority displace names well-known and widely used for 140 years.

CARLETON R. BALL
U. S. Department of Agriculture, Washington, D. C.

Cancer Research and Benefit to Patients

It cannot be otherwise but that the tenacity with which the practitioners of applied or practical research claim omnipotence is matched by the pertinacity with which the practitioners of academic or pastime research claim holiness. While the former clothe their activity with the semantics of utility, their basic motive is, of course, the acquisition of material things. And while the latter clothe their activity with the semantics of increasing knowledge, their basic motives are, of course, self-amusement and fame. Such camouflage is necessary, we humans being what we are. But the conflict between the motives of the two groups is in considerable part responsible for what Prof. George Shull so aptly calls "the historical phenomenon" of the "long interval which" elapses "between the making of a fundamental discovery and the general understanding of its importance and full realization of its benefits" (*Science*, 1946, 103, 547).

Nowhere today is this delay more unhappily evident than in the field of cancer research. The accumulated data of Rous, Shope, Coley, Bittner, Strong, Andervont, Green, Greene, Williams, Taylor, Furth, Twombly, Cowdry, Diller, Bawden, Pirie, Stanley, Wycoff, Kunitz, and others indicate beyond peradventure the path for getting at something of practical benefit to the cancer patient of the future other than surgery and radium.

The demonstration that mother's milk may contain a transmissible agent productive of malignant growth—call it a virus or what you will—is evidence enough of an autogenously produced chemical compound type which is responsible for that distortion of ordered cell growth which results in malignancy and death of the individual. Yet where is the proposal that mothers with family histories of cancer should be warned against breast-feeding their infants? One such I have seen, but this was so buried in the literature that its excavation is impossible.

And where is the proposal that workers acquainted with this principle of transmissible agent should get together as a team, pool their respective experiences, knowledges, and ideas to undertake a concerted, coordinated, cooperative, organized attempt at isolation, identification, and investigation of the offending chemical compound—not separate and alone as they are now doing, but under one roof, in daily contact with each other, exchanging results, information, and ideas to the sole end of bringing as early as possible something of practical benefit to the cancer patient?

It is said that the academic scientists are too egoistic to work together, too set in their opinions, too unwilling to consider alternatives, too determined on fame. If this is so, they should take a leaf from their confreres in industrial research. Here, too, there are able scientists, working together in both applied and fundamental research to bring about results of practical utility. And our best brains in physics worked together in organized cooperation to produce the greatest destructive agent known to man. So why can't the same be done constructively to produce deflation of the second greatest scourge of human living, namely, cancer? Surely logic, reason, common sense, and the call of humanity make such procedure much to be desired.

FREDERICK S. HAMMETT
The Lankenau Hospital Research Institute
North Truro, Cape Cod, Massachusetts

Book Reviews

Marine microbiology: a monograph on hydrobacteriology. Claude E. ZoBell. Waltham, Mass.: Chronica Botanica; New York: G. E. Stechert, 1946. Pp. xv + 240. $5.00.

It is an extremely difficult business to organize the large number of scattered studies on the microorganisms and microbiological processes of the sea. Work has been done by many people whose interests have varied widely, and papers in all languages have been published in uncommon journals. Many of the questions raised have not been satisfactorily answered. In addition, researches in this field seem to develop from the general to the extravagantly minute in an explosive fashion. A very persistent, almost evangelical temperament is necessary to find, sort, and squeeze all of these into a comprehensible system. It does not come easily.

Dr. ZoBell is one of the few scientists in the country who, by experience and interests, can be regarded as capable of such a project. He has diligently catalogued his sources and edited them to the bone. Specialized reviews of the field have been published at intervals, but *Marine microbiology* is the first attempt since Benecke's digest of 1933 to bring together the whole literature. The work is complete, and inasmuch as little research has been published during the past five years, it is virtually an official introduction to new work.

It is not possible to treat such a large group of sources critically, and some may feel that Dr. ZoBell is overzealous to establish the place of bacteria and other microorganisms in the economy of the sea. Oceanographers, marine ecologists, geologists, chemists, and applied biologists have been concerned for a long time with the degree to which microorganisms determine the composition of waters and sediments, and with their significance in the organic food cycles of local areas. The relatively recent concentrated microbiological programs under Dr. ZoBell at the Scripps Institute of Oceanography and under Dr. Waksman at the Woods Hole Oceanographic Institution have described the qualitative boundaries of the functions of marine bacteria. It is much more difficult to represent the processes in a quantitative fashion, and reading *Marine microbiology* emphasizes the need for studies in this direction if the value of investigations in the field as an integrating science are to be realized.

The book has been organized about the predominant research tendencies. There are chapters on the numbers, types, and distribution of organisms; the influence of physical and chemical environment; bacterial transformations of organic matter; assimilation and regeneration of inorganic nutrients; parasitic, commensural, and antibiotic relations; and sanitary and other practical applications. There are also sections on the microbiology of marine air, and inland salt and fresh-water lakes. Full bibliographic references are given, and there are subject and author indexes, so that the book is an invaluable source finder.

CHARLES E. RENN
Woods Hole Oceanographic Institution

Physical chemistry for premedical students. **John Page Amsden. New York and London: McGraw-Hill, 1946. Pp. ix + 298. (Illustrated.) $3.50.**

The inclusion of physical chemistry in the already full curriculum of the premedical student has necessitated the writing of textbooks which can be used in a course of only one semester. This book has been written with the object of meeting this demand and treats only those subjects which may be of value to the premedical student. Two admirable features are: (1) the inclusion, as the first chapter, of a discussion of dimensions and units, and (2) a useful correlated list of visual aids at the end of the book. The subjects covered are gases, liquids, electrolytic and nonelectrolytic solutions, chemical equilibrium, hydronium ion, oxidation and reduction, speed of reaction, catalysis, adsorption, colloids, and the Donnan equilibrium. Bronsted's concept of acids and bases and the hydronium ion is used throughout the book. Suggested experiments which may be used as lecture demonstrations are frequently given. The use of the equations developed in the text is illustrated by solved examples. A set of problems of increasing difficulty is included at the end of each chapter. The use of calculus is held to a minimum in the derivation of the equations, and the mathematical requirements of the students are an ability to solve quadratic equations and to use logarithms.

While the scope of the book seems adequate, many incomplete or inaccurate statements and discussions have been noted. Probably the most important of these occur in the first chapter, on units and dimensions. Zero degrees centigrade is defined as the freezing point of pure water at one atmosphere pressure without mentioning the necessity of the water being saturated with air at this pressure; absolute zero is given as $-273.13°$ C. rather than $-273.16°$ C.; one calorie is given as equal to 4.187 joules rather than 4.185 joules; the atmosphere is defined in terms of the height of a column of mercury without introducing the concept of the measurement being made at 0° C.; and no clear distinction is made between international and electrostatic units of electricity. Among the incomplete and even erroneous discussions which may easily lead to gross misconceptions are those concerned with the deviations of real gases from the ideal gas laws and with the critical temperature and critical pressure. Other major criticisms concern the statement that the equilibrium constants are a function of the temperature only, and the fact that the experiment described on page 163 does not clearly distinguish between the effect of temperature on the rate of reaction and on the equilibrium. Also, there is no mention of the assumptions made in the solution of such problems as the calculation of the hydronium ion concentration in solutions of a salt of a weak acid and a weak base.

In the opinion of the reviewer the over-all criticism of the book is that too great a simplification has been made of the physical phenomena discussed at too great an expense of accuracy. However, only the author and those who may use this book can resolve this difficulty with respect to the aims of their courses in physical chemistry for premedical students.

SCOTT E. Wood

Yale University

Advancing fronts in chemistry. **Vol. I: *High polymers*. Sumner B. Twiss. (Ed.) New York: Reinhold, 1945. Pp. 196. (Illustrated.) $4.00.**

In this volume, containing 10 lectures given in 1944, aspects of two general problems are covered: the mechanism of building up of the polymer molecule, and the physical properties of high polymer systems as related to molecular characteristics.

Four lectures are devoted to the first subject. A paper by E. C. Pitzer discusses possibilities of catalytic preparation of important monomers from hydrocarbons and reviews briefly methods of preparation of several industrial catalysts. The inclusion of such material, rarely given in a monograph of this kind, is to be recommended. W. H. Stockmayer considers the kinetics of polycondensation reactions and the formation of branched and cross-linked structures. This chapter should be particularly useful to those desiring an insight into the physical picture, principal results, and assumptions made without following the calculations in detail. Two articles are devoted to chain polymerization reactions. The nature of the initiation catalyzed by free radicals is discussed in detail by C. C. Price. F. R. Mayo's chapter deals to a large extent with effects of the medium in solution polymerization.

Polymer solids and concentrated solutions form the subject of the other six chapters. Two of these, by H. Mark and S. S. Kistler, respectively, contain a general description of features common to all chain polymers as well as some of those which impart to each type a set of characteristic mechanical properties. The situation is examined further in an extensive paper by W. O. Baker, with particular reference to polyesters and polyamides, on the basis of X-ray diagrams, dielectric and mechanical performance. The behavior of concentrated solutions under periodic stress is considered by J. D. Ferry. Detailed attention is given by E. Ott to two parameters, the average degree of polymerization and the molecular weight distribution, as affecting bulk properties as well as thermodynamic and viscosity behavior in solution for cellulose esters. The series is concluded by M. Harris, who discusses the elasticity of wool in relation to chemical structure and its modifications as produced in the laboratory.

This monograph can well be recommended to the research worker in other fields and to the practical polymer technologist who wishes to familiarize himself with some more "theoretical" concepts. Those actively engaged in one or the other phase of polymer research will find the information presented and the references given very useful.

ROBERT SIMHA

National Bureau of Standards, Washington, D. C.